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RESEARCH DEPARTMENT

FURTHER ACOUSTIC TESTS IN BROADCASTING HOUSE, LLANDAFF

Technological Report No. PH-2/2
UDC 534.861.1 1967/38

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SUMMARY

This report summarizes the results of three acoustic surveys made at Broadcasting House, Llandaff, prior to its being brought into service. In general the studios are satisfactory, but recommendations are made for modification to a few areas to reduce ventilation noise or speech colouration caused by the ceiling resonances, to which attention was drawn in a previous report.

1. INTRODUCTION

Research Department Report B-089/5 gave results of measurements in the partly completed studios in the new Broadcasting House at Baynton House, Llandaff. Final measurements on acoustics, noise and sound insulation were carried out during three visits between November 1966 and February 1967, and listening tests were made in conjunction with Mr. Gundry of C.E.S.B.'s staff. This report gives the results of the measurements.

2. RESULTS OF MEASUREMENTS

2.1. The Sound Studio Block

This section comprises Studios Nos. 1 to 6 and a Narrator's Studio, with their associated control cubicles and recording rooms. Studios 1, 2 and 3 are at ground floor level and Studios 4, 5 and 6 on the first floor. Reverberation times, noise levels and sound insulations were measured in all these areas.

2.1.1. Studio 1 and its Associated Areas

The acoustic treatment in Studio 1 is spaced away from the structural walls on an angle-iron framework to conceal all services. Vibration of this framework has been shown in earlier tests (reported in Research Department Report No. B-089/5) to be capable of acoustic excitation, and additional stiffening by timber props was subsequently installed to avoid re-radiation of sound at the resonance frequencies. The final designed reverberation time for Studio 1 on the basis of the volume included within the confines of the acoustic treatment was 1·5 sec. This was an increase over the original design value and necessitated the substitution of stiff faced boxes for approx 110m^2 (1200 ft^2) of absorbing treatment.

Fig. 1 shows the reverberation times measured at various times since the completion of the absorbing treatment. Curve (*a*) was measured on site with the orchestral rostra stacked in the centre of the studio. It was obvious that the absorption at all frequencies was excessive; the reverberation time was only 1·3 secs. at mid frequencies and fell steadily with decrease of frequency from 250 Hz. A close examination of the studio, drawings and calculations in the light of this reverberation deficiency revealed many differences from the design assumptions. The absorption of the floor was calculated on the assumption that it was of wood block on concrete, whereas, in fact, it is of wood strip on battens and would therefore be expected to absorb at low frequencies. The ceiling is certainly of wood as was assumed but with a void for lighting and ventilating equipment above. No allowance had been made in the calculations for audience seating or orchestra.

Some additional absorption may be expected from the construction of the absorbing treatment. The absorbing units are fastened by small brackets to timber battens on the angle-iron framework leaving gaps between the absorbers and the framework which vary in width from zero up to approximately 6 mm (¼ in.). There must be considerable transmission of energy into the space behind the absorbers and absorption by the rear surfaces of the absorbers and the structural walls. The gaps may also act as slot resonators with natural frequencies determined by the gap width and the depth of the space behind. Experiments are being undertaken in Research Department to determine the absorbing properties of this form of construction from measurements on scale models.

Curve (*b*) in Fig. 1 was measured from the decay of sound energy following short orchestral chords. The fall of reverberation time between 630 Hz and 4000 Hz is due to the presence of the

orchestra; the apparent rise of reverberation time below 250 Hz may well be due to "ringing" of orchestral instruments. Curve (*c*) was obtained by computer analysis of a reverberation test tape with the orchestral rostra in their working positions. The agreement between this curve and curve (*a*) shows that the distribution of the rostra had little effect.

Subjectively the studio was "dead", particularly when listening at floor level. The orchestral players found it difficult to hear each other and it was decided that some of the modular acoustic treatment should be interchanged to provide stronger early reflexions in the orchestral area. It was surprising that at the optimum microphone position, which is high and near the balcony, the lack of low-frequency content was not subjectively obvious. Artificial reverberation is added for broadcasts.

The reverberation time curves of the Cubicle of Studio 1 and Recording Channel W1 (Fig. 2) indicate that these two areas are acceptably close to the design time of 0·3 s. There is an increase to 0·39 s at high frequencies in the case of the Cubicle, but this is unlikely to give rise to any problems in operation.

The background noise levels in Studio 1 suite are plotted in Fig. 3 together with the criterion curve for permissible background noise in a music studio. It can be seen that only the studio (curve (*a*)) failed to meet the criterion, being about 5 dB in excess over the range 250 Hz to 1 kHz. A "rattle" could be heard in the studio and it was found to be loudest near the door to the cubicle lobby. The noise was traced to the heater battery which precedes the main inlet fan in the plant room overhead and is understood to be caused by steam condensation in the heat exchanger. If this effect can be eliminated, the background noise levels in the studio may be reduced to the levels defined by curve 3(*d*).

Fig. 4 shows the insulation of Studio 1 from its Recording Channel (curve (*a*)) and its Control Cubicle (curve (*b*)), and of the Control Cubicle from the Recording Channel W1 (curve (*c*)). Criterion curves for the required insulation appropriate to these areas are also included in the graph. The average insulation from the cubicle to the studio (53·5 dB) is 11 dB below the average of the criterion curve, and when corrected for the studio absorption and partition area, gives an average sound reduction index of only 44·5 dB. The partition is of double-leaf plastered brickwork containing a double-glazed window and since this construction should have a sound reduction index of at least 50 to 55 dB the partition should be examined for flanking paths or constructional weaknesses. The same observation applied to the studio-to-recording room partition. In this case the average insulation is 7 dB below criterion and the average sound reduction index is 48·8 dB showing that a similar weakness exists in this section of the studio wall.

The insulation from the Control Cubicle to Recording Channel W1 is about 5·6 dB below criterion, but it is possible that this is due to minor weaknesses of the seals of the inter-connecting double doors. The addition of a third pane to the double-glazed observation windows in each of these partitions may help to increase their sound reduction indices. It is recommended that this be done when money is available.

The roof and two walls of Studio 1 are exposed to external noises, particularly those of traffic on the adjacent road and aircraft noise. The design of the roof followed the successful elimination of aircraft noise from the Glasgow television studio and a similar design criterion of 70 dB average sound level difference was applied. The construction is of 150 mm (6 in.) of reinforced concrete carrying, over an air space, a 50 mm (2 in.) woodwool slab roof with a 38 mm (1½ in.) concrete screed. The outer septum is supported on resilient pads and the airspace varies between 450 mm (18 in.) at the edges and 225 mm (9 in.) at the centre to provide a rainwater fall to a centre gutter. In the original design this gutter drained through two rainwater pipes which pierced both layers of the roof but this sound transmission path has now been eliminated by leading the drainpipe down the outside of the studio.

Beneath the structural roof is a void containing lighting and ventilating equipment and the floor is boarded to provide a ceiling for the studio. Access to this void had to be provided by a door which pierced the walls and taking into account the area of this door and its position above the boarded ceiling it was specified that it ought to achieve a sound level difference of 45 dB if it was not to degrade the overall insulation.

The access door to the void had not been fitted at the time of any of the measurements described in this report and estimates of the performance of the roof had therefore to be made by specialised techniques which would eliminate the effect of the flanking paths. These results indicated an average sound level difference lying between 65 and 70 dB for transmission through the structural roof and an additional 20 dB for transmission from the void to the studio floor. The total sound level difference from the outside should therefore be better than 80 dB and aircraft noise should never be heard on transmission. The walls are of two leaves of brickwork each 220 mm (9 in.) thick connected by resilient ties and covered on the inside by the acoustic treatment and outside by river boulders. The insulation of these walls should be in the region of 65 dB and will be adequate to exclude traffic and aircraft noise.

2.1.2. Studios 2, 3 and Narrator's Studio

The acoustic treatment in Studio 2 up to a height of 2·5 m (8 ft 3 in.) is completely covered by fabric, whereas above this height the acoustic treatment consists of hardboard-faced bonded absorbers together with a few wide-band absorbers. It was thought that the reverberation times of the upper and lower halves of the studio might differ as a result of this variation in acoustic treatment and two sets of five measurements of reverberation time were made - one set using a low microphone stand and the other with a "lazy-arm" stand set to a high elevation. Fig. 5 shows the reverberation times* computed from the five high microphone positions (curve (*a*)), the average for all ten positions (curve (*b*)), and for the five low positions (curve (*c*)). It will be seen that at frequencies above 500 Hz the reverberation time in the upper half of the studio exceeds that in the lower half by up to 15%. The average reverberation time curve is satisfactory except perhaps for a minimum at 125 Hz which is not likely to be subjectively disadvantageous. Fig. 6 shows the reverberation times measured in the Control Cubicle to Studio 2 (curve (*a*)), and Recording Channel W2 (curve (*b*)). For both rooms the plotted curves have broad maxima, centred on 500 Hz which could easily be reduced if necessary.

The reverberation-time frequency characteristics of Studio 3, Control Cubicle 3, Recording Channel W3 and the Narrator's Studio common to Studios 2 and 3 are displayed in Fig. 7. Studio 3 is designed to be divided into "live" and "dead" ends but at the time of the most recent survey the dividing curtain had not been installed and consequently only the values of reverberation time for the whole studio were measured. The high reverberation times measured at frequencies above 500 Hz may be partly attributed to the absence of the curtains and studio carpet. The reverberation times of Control Cubicle 3 and the Narrator's Studio are satisfactory, but the reverberation time measured in Recording Channel W3 has a conspicuous broad maximum centred on 500 Hz as shown in curve (*c*).

Fig. 8 displays the noise levels in the various areas associated with Studio 2; by comparing curves (*a*) and (*b*) with the criterion curve (*d*) it will be seen that the background noise levels in the studio and Control Cubicle are satisfactory. However, curve (*c*), the noise levels in Recording Channel W2, exceed the permissible noise criterion curve (*d*) by up to 6 dB at 250 Hz. The measured noise levels in the Narrator's Studio, shown together with the criterion curve for a talks studio in Fig. 9, will be entirely satisfactory when the cubicle is used in conjunction with programmes originating in Studio 2. When used with drama productions from Studio 3 the noise levels may be only marginally satisfactory since between 63 Hz and 300 Hz they just exceed the drama criterion which is 4 dB lower than the talks studio criterion.

Fig. 10 curve (*a*) shows that the background noise levels in Studio 3 exceed the criterion curve (*d*) for a drama studio by as much as 8 dB at 125 Hz. Noise levels in the Control Cubicle are satisfactory but those shown in curve (*b*) for the Recording Channel W3 are excessive, the levels being 4 dB above the criterion in the range 125 Hz to 500 Hz.

Report B-089/5 included all measurements of sound insulation in the areas excepting those from Control Cubicle 2 to Recording Channel W3 and from the Narrator's Studio to Studios 2 and 3. The results for these areas are now provided by Figs. 11 and 12 together with relevant minimum permissible values. Curve (*a*), the insulation of Control Cubicle 2 from Recording Channel W2 lies above the minimum requirement at all frequencies except between 125 Hz and 180 Hz but shows a coincidence effect minimum at 1·4 kHz. The depth of the dip suggested that the observation window in this partition was constructed from two panes of the same thickness. This point was taken up with Building Department who have confirmed the fact; however, since the insulation is found to be satisfactory no change is contemplated at present. The partition separating Studio 2 from the Narrator's Studio is of similar construction, having a double-glazed observation window set in an 280 mm (11-inch) cavity brick wall, and, as curve (*b*) shows, it has a similar insulation curve. However, the required insulation of a talks studio from a music studio, given by curve (*d*) is up to 10 dB greater than that provided by the partition, and if the Narrator's Studio is to be used in conjunction with a drama production in Studio 3 while a programme of orchestral music is in progress in Studio 2, the insulation required to meet the background noise criterion curve of a drama studio will be an additional 4 dB above curve (*d*) at all frequencies. The only way to obtain this insulation would be by adding an extra leaf to the partition and triple-glazing the observation window.

Comparison of curves (*a*) and (*c*) in Fig. 12 shows that the insulation between Recording Channel W3 and Control Cubicle 3 is adequate except perhaps at low frequencies. It was not possible to measure the insulation of Studio 3 from the Narrator's Studio at frequencies above 350 Hz because of the high background noise in Studio 3 at the time of the test but the trend of curve (*b*) indicates that the insulation is probably satisfactory except perhaps at the lowest frequencies.

* It should be noted that the reverberation times quoted in this report were obtained by reading the initial slopes of the decay curves. The frequencies at which long-tailed decays were detected are indicated where applicable on the graphs.

2.1.3. Studios 4, 5 and 6

The insulations between adjoining areas of Studios 4, 5 and 6, which are arranged in adjacent suites along one side of the Sound Studio Block first floor corridor, were measured on a previous visit. During the survey of November 1st to 4th, 1966, the background noise levels and reverberation times were measured in all the studios and cubicles of this section. In addition, the insulation from the exterior was checked by firing a stage maroon in the forecourt and making simultaneous measurements of the sound pressure levels on each side of the exterior wall of Studio 5.

Fig. 13 displays the one-third octave sound pressure level differences between the forecourt and Studio 5. These were measured at one pair of microphone positions only, and consequently the results should be treated only as a general indication of the properties of the partition. It will be noted that although the low-frequency insulation is very good the curve has an extremely low gradient. The reduced gradient is most likely attributable to the presence of two triple-glazed slit windows which extend from floor to ceiling on each side of the studio overlooking the forecourt and which are designed to be completely openable. Slight imperfections in the sealing of the frames could account for the shape of the curve. Road traffic noise was just perceptible in Studio 5, which was subjectively judged to have the lowest insulation from the exterior of the three studios in this part of the building.

Measurements of reverberation times in the studios and cubicles of this section all show pronounced "double decays" at low frequencies. The reverberation-time frequency characteristics of Figs. 14 to 16 were all obtained by reading the initial portions of the low-frequency decays. As indicated in Report B-089/5, the second slopes are produced by high-Q resonances of the lightweight steelwork supporting the suspended ceilings. The decay times of the initial slopes indicate that the acoustic design of the studios and cubicles is satisfactory except for the anomalies introduced by the ceiling structures.

All the curves for these three talks studios rise above 0·4 s at high frequencies, which was expected to make speech sibilants unduly prominent, but a series of listening tests on 2nd January 1967 revealed that neither the extended high-frequency reverberation, nor the low-frequency resonances of the false ceiling structure caused any marked degradation of speech quality in the studios and no alterations to their treatment are contemplated at present.

Background noise levels in these areas are plotted in Figs. 17, 18 and 19. In Studio 4 and its Cubicle, noise levels are satisfactory apart from the region 125 Hz to 355 Hz in the studio where they exceed the noise criterion by a small margin. In Studio 5, Cubicle 5 and Studio 6 the noise level is entirely satisfactory but in Cubicle 6 the criterion is exceeded by 3 dB at 125 Hz. This is not likely to be serious.

2.2. Technical Block

This part of the centre comprises Editing Channel W7, Studio 7, Editing Channels W8 and W9, and Studio 8 and its Cubicle which form the Continuity Suite. The rooms are located along one side of a first floor corridor in the order in which they are listed above. Measurements of background noise levels and reverberation times were made in W7, Studio 7, Studio 8 and Cubicle 8 and the insulation of Studio 7 from W7 and W8 was determined. In addition the insulation of Studio 7 from the exterior of the building was checked by firing a maroon in the courtyard and analysing the recorded sound levels on each side of the external wall through one-third octave filters.

2.2.1. Recording Studio 7 and Editing Channels W7 and W8

Fig. 20 shows the reverberation times measured in Studio 7 and its associated Editing Channel. In Studio 7 the ceiling structure was stiffened experimentally at the time of the previous measurements in order to reduce the "ringing" of the hangers for the acoustic tiles. No double-sloped decays were detected within 30 dB of the excitation level, indicating that the modifications had succeeded in reducing the oscillations of the ceiling structure. Nevertheless, the reverberation time in the studio at 63 Hz (0·78 s) is nearly double that at 125 Hz (0·36 s) and in subsequent octave bands. Speech tests showed that the studio will be acceptable for speech since the time-duration of speech syllables is short compared with the warbled tone-bursts of the test, and speech will therefore not excite the undamped resonances responsible for the extended reverberation times at low frequencies. The reverberation characteristic of Editing Channel W7 displays a broad maximum centred on 500 Hz, but that of Channel W8 analysed by computer in one-third octave bands from a test tape and shown in Fig. 21 shows a more uniform decrease towards higher frequencies. Noise levels in Studio 7, shown in Fig. 22, exceed the permissible levels by up to 6 dB between 125 Hz and 2·8 kHz. No measurements of background noise were taken in Editing Channel W7 as this area is not connected to the ventilation system.

In Fig. 23 sound insulation curves are shown for the partitions separating Studio 7 from the adjacent Editing Channels W8 and W7. The figure also shows the insulation criteria for the sound pressure level difference between a studio and its

associated recording channel, and a studio to a recording channel or cubicle monitoring a different programme. From these data it will be seen that the partition separating Studio 7 from Editing Channel W8 (a triple-leaf construction of breeze and brickwork together with a triple-glazed observation window) meets both criteria, i.e. with W8 monitoring the programme originating in Studio 7 or monitoring a separate programme; but the partition separating Studio 7 and W7 (a double-leaf brickwork partition with a triple-glazed observation window) just fails to meet either of the two criteria.

Fig. 24 shows the insulation of Studio 7 from the exterior measured as in the case of Studio 5. Here again the data should be treated only as a general indication of the insulation properties of the partition as only one microphone position was used on each side of the wall. It would appear that the performance of the partition is satisfactory, notwithstanding the limitation imposed by the triple-glazed opening window.

2.2.2. Continuity Suite

The reverberation times shown in Fig. 25 curves (*a*) and (*b*) are those for the Continuity Studio and its Cubicle respectively. The low-frequency decays in the studio contained "second slopes" which commenced at as little as 10 dB below the excitation level and had decay times in excess of 2·0 s. It was to be expected therefore that speech from the studio would be "boomy" - an appraisal which was confirmed by the operational staff and in independent listening tests on 2nd January 1967. The local staff had already connected a "bass-cut" filter into the studio output as a short-term expedient.

It has been proposed that the light-gauge steel members supporting the suspended ceiling be treated with vibration damping tape (a foil-backed adhesive plastic preparation) in an attempt to reduce the low-frequency colourations on the studio output, and this will shortly be done on an experimental basis. Except for some excessively long second decays at 63 Hz, the reverberation time curve for the Continuity Control Cubicle is satisfactory.

The noise levels measured in the Continuity Suite are shown in Fig. 26 from which it may be seen that the noise level in the studio is satisfactory, but that in the Control Cubicle exceeds the criterion curve by about 3 dB at 1 kHz.

2.3. Echo Room

The reverberation characteristic of the Echo Room is shown in Fig. 27. The curve was obtained by computer analysis of a test tape and shows that the room has a marked lack of absorption over a broad frequency band centred on 1 kHz. It will be necessary to treat the room with wide-band mid-frequency absorbers to remove the maximum in the curve and thereby provide a reverberation characteristic more suited to the various types of programme that will require echo facilities.

3. DISPOSITION OF ACOUSTIC TREATMENT AND ITS EFFECTS

In all the studio areas tested, the modular acoustic treatment had been arranged so that the smooth painted surfaces of bonded absorbers faced similar modules on the opposite walls, and absorbers covered with perforated hardboard were also placed directly opposite similar units. As a result of this symmetrical distribution, "flutter-echoes" occurred to a greater or lesser extent in all studios and cubicles. It should be emphasized again that in flush-walled studios such as these, good diffusion can be gained only by an irregular distribution of the absorption, taking care to ensure that reflecting surfaces or similar absorbers do not face one another. Since the treatment is modular and detachable, it will be possible to correct this fault without taking the studios out of service.

4. DISCUSSION AND RECOMMENDATIONS

4.1. General Comments

This report gives the results of all tests of acoustics, noise and insulation which it has been possible to carry out up to the time at which the studios went into full operation. In the great majority of the respects, the studios already fulfilled all design requirements, while other defects such as those concerning ventilation noise are being made good by adjustments as time permits.

As pointed out in the earlier report, the extreme financial difficulties attending the construction of the studios prevented other adjustments from being carried out before the service date, but there is nothing amiss with the design or construction of the studios which is not capable of simple correction. The adjustments required are summarized below under the headings of acoustics, noise and sound insulation.

4.1.1. Acoustics

Studio 1 falls short of the designed reverberation time partly as a result of anomalous absorption which has not been fully explained. The acoustic quality is generally good, the diffusion and clarity being satisfactory. Nothing can be done at present to correct the excess absorption but it is hoped that experiments with scale models, now under way by Research Department will indicate the cause by the time money is available for adjustments.

Studio 2 should be satisfactory and the effect of the "two level" absorption will be awaited with interest.

Studio 3 may have less difference in acoustics than desirable between the live and dead ends. Easy adjustments can be made and the experience will be of use in the design of Birmingham Pebble Mill studios.

A few areas (Studio 2, Control Cubicles 2 and 3 and Recording Channels W3 and W7) show broad maxima exceeding the design figure at middle frequencies, and thus will require modifications of the acoustic treatment. In all areas of Studio Suites 4, 5 and 6 the reverberation characteristics rise slightly at high frequencies, but this may be curable by rearrangement of the absorbers to avoid the opposition of reflecting areas - a change that will also help to remove flutter echoes.

Continuity Studio is affected by the effects of ceiling vibrations as discussed in the previous report and remedies have already been discussed. Since the unwanted double decays in this and other studios can be removed by minor changes of the ceiling design, their existence has merely been indicated in the graphs and not included as part of the overall reverberation characteristics. It was assumed that the normal low-frequency responses of the studios were represented by the initial portions of the decay curves, and on this basis the acoustical design of the studios in which double decays occurred at low frequencies can be considered to be reasonably successful.

4.1.2. Noise

The attainment of the specified background noise levels due to ventilation is the responsibility of the sub-contractor. All results have been communicated to them through Building Department.

4.1.3. Sound Insulation

In assessing the results of sound insulation measurements, use has been made of a series of empirical acceptance curves depending on the uses of the respective areas concerned. These will be fully described in a forthcoming report. On the basis of these curves all partitions in Studio 1 Suite would benefit by some improvement, though in the case of that between W1 and the Control Cubicle improved door seals may bring it up to the designed figure. The specific shortcomings have been mentioned in Sections 2 and 3 and in the previous Report B-089/5 and the attention of Building Department has been drawn to them.

Report B-089/5 indicated that the insulations of Studio 2 from Editing Channel W2 and of Studio 3 from Editing Channel W3 may be insufficient because the design criterion adopted for these two partitions was that of a studio to its own cubicle. If it is found necessary to increase the insulation to meet the criterion of a studio to a recording channel, the incorporation of an additional pane in each of the observation windows in these partitions should be sufficient.

The use of Studio 3 with its Narrator's Studio when Studio 2 is in use for music may be restricted because the sound insulation between Studio 2 and the Narrator's Studio is insufficient for simultaneous music and drama.

Sound insulation between the areas in all the talks studio suites are satisfactory as is the protection of the studios from noise external to the building.

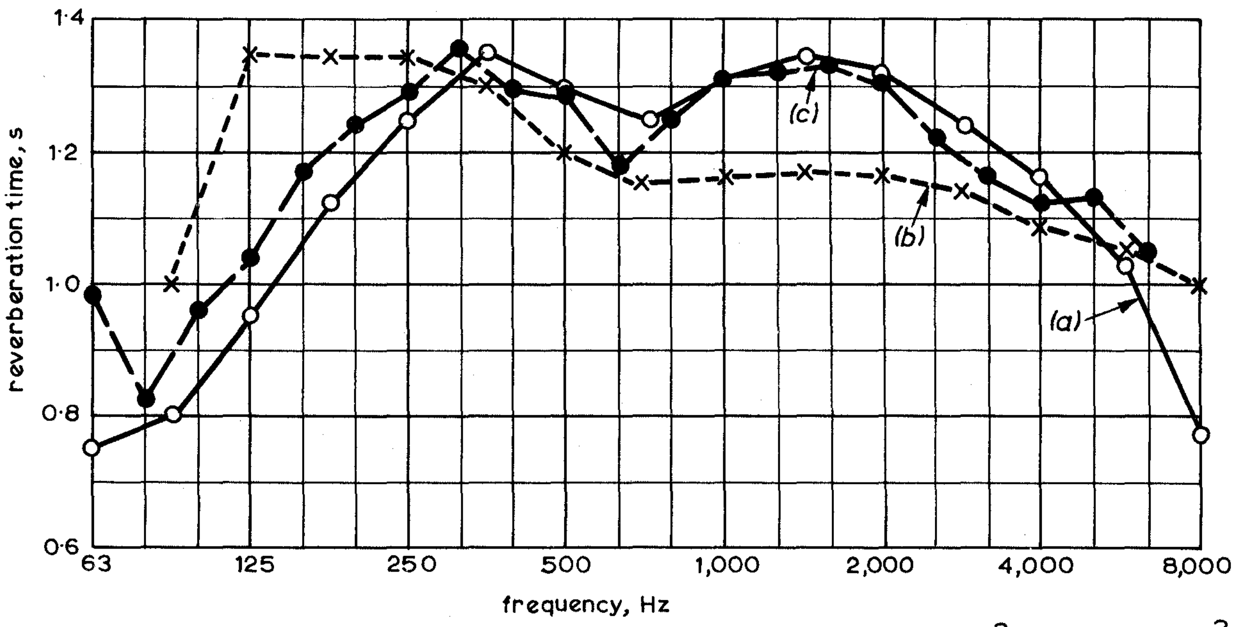

Fig. 1. Reverberation times in Studio 1. (Volume: 3,760 m^3, 133,000 ft^3)

(a) Measured on site - rostra stacked in centre of studio
(b) Measured from orchestral chords at rehearsal
(c) Test tape analysed by computer.

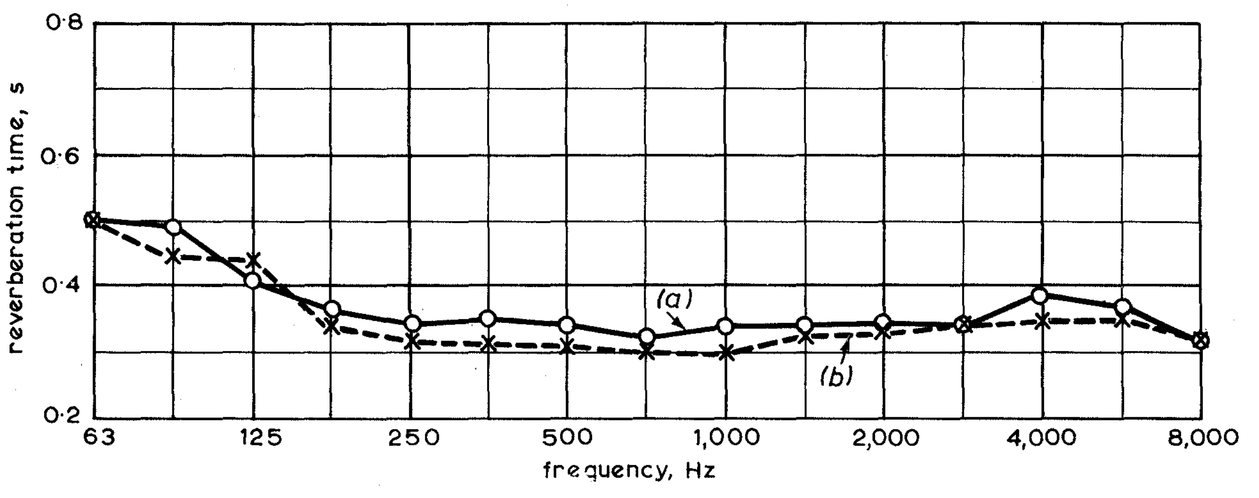

Fig. 2. Reverberation times in Studio 1 Suite

(a) Cubicle to Studio 1. (Volume: 154 m^3, 5,430 ft^3)
(b) Recording Channel W 1 (Volume: 90 m^3, 3,180 ft^3)

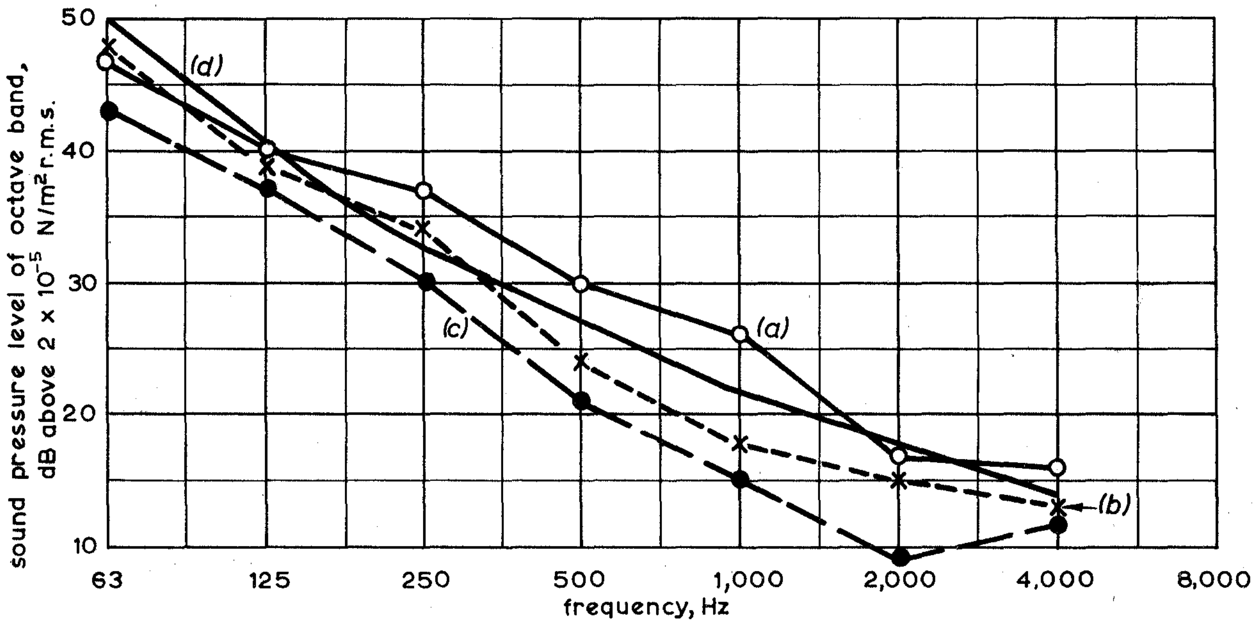

Fig. 3. Background noise levels in Studio 1 Suite

(a) Studio 1 *(b)* Control Cubicle 1 *(c)* Recording Channel W1

(d) Criterion curve of permissible background noise in sound studios

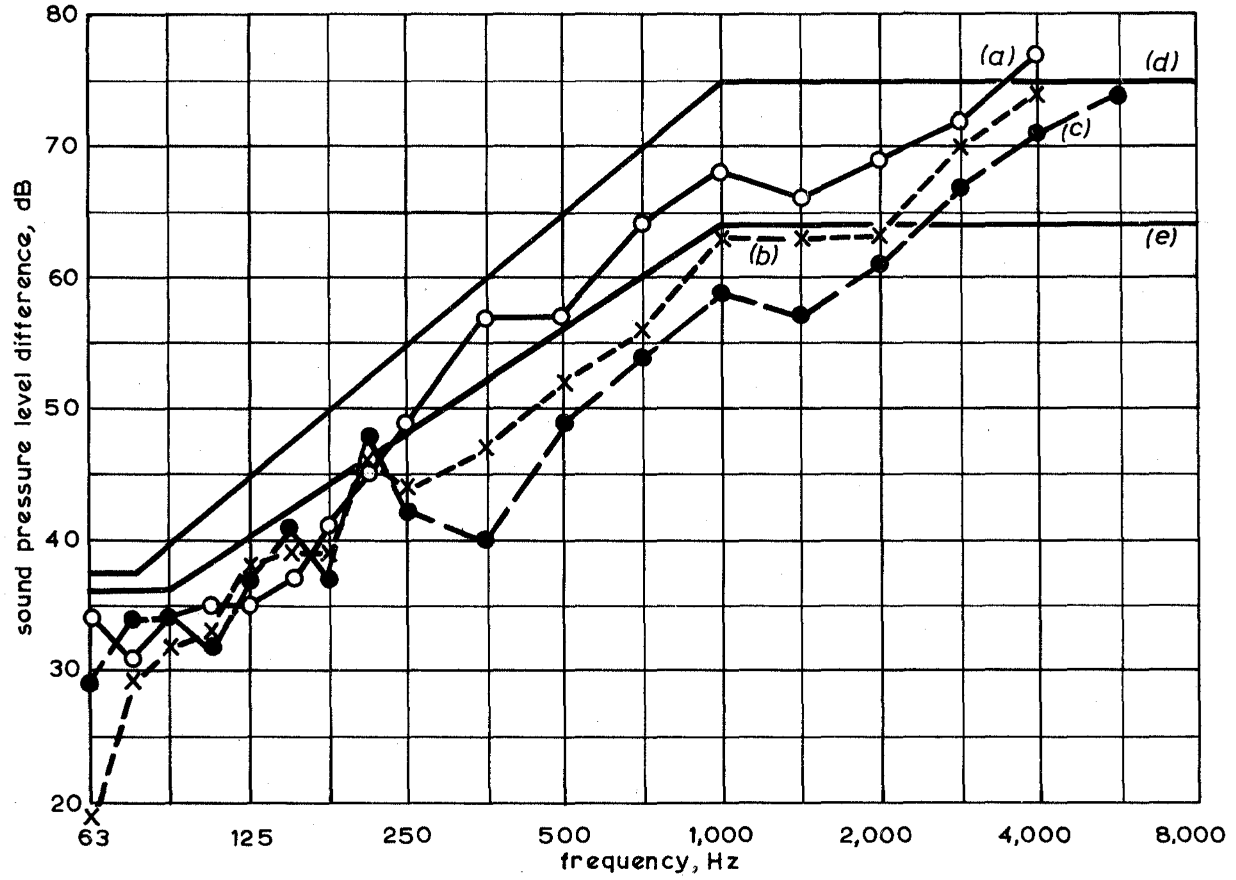

Fig. 4. Sound insulation in Studio 1 Suite

(a) Recording Channel W1 to Studio 1 (criterion *(d)* applies)

(b) Control Cubicle to Studio 1 (criterion *(d)* applies)

(c) Control Cubicle to Recording Channel W1 (criterion *(e)* applies)

(d) Insulation criterion for Cubicle to Music Studio.

(e) Insulation criterion for Cubicle to Recording Channel

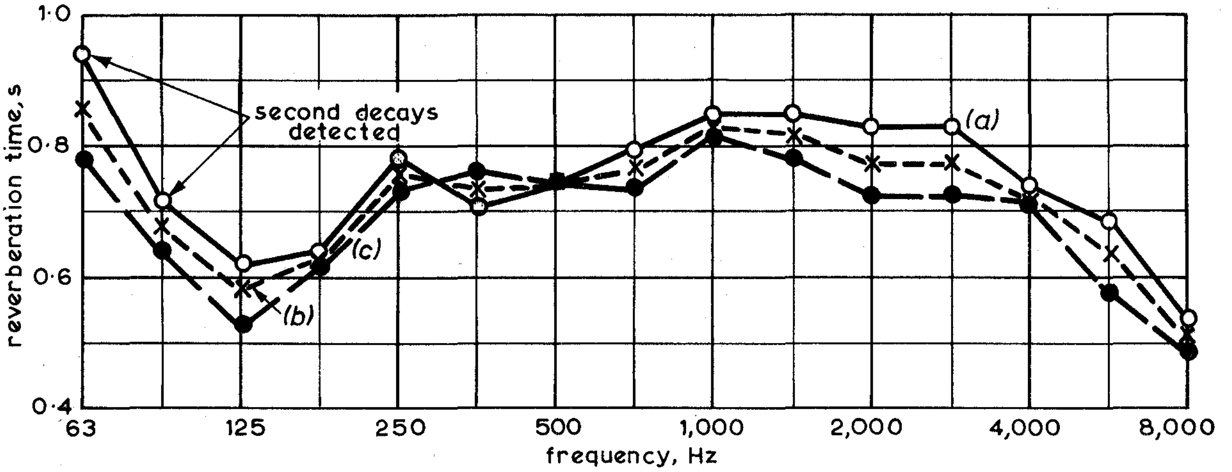

Fig. 5. Reverberation times in Studio 2. (Volume: 648 m^3, 22,900 ft^3)

(a) Mean of five high microphone positions
(b) Mean of all ten microphone positions
(c) Mean of five low microphone positions

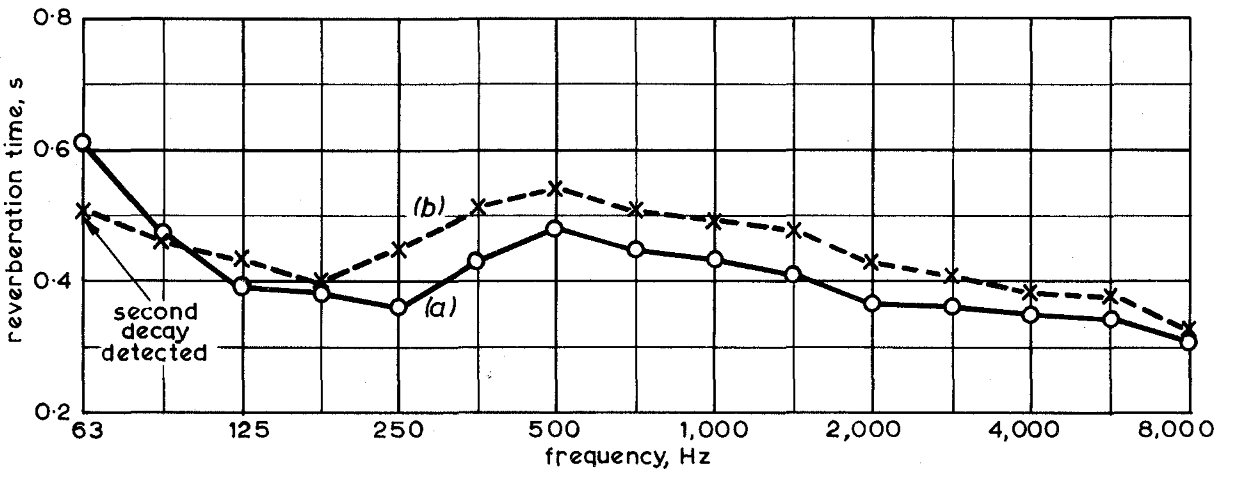

Fig. 6. Reverberation times in Studio 2 Suite

(a) Studio 2 Cubicle. (Volume: 88·4 m^3, 3,120 ft^3)
(b) Recording Channel W2. (Volume: 75·8 m^3, 2,680 ft^3)

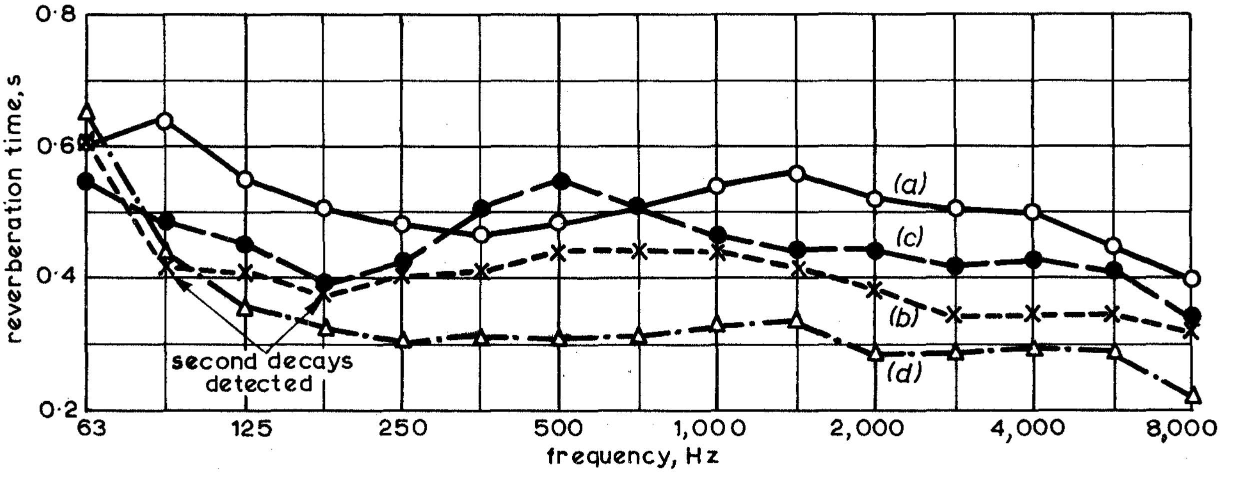

Fig. 7. Reverberation times in Studio 3 Suite

(a) Studio 3 (Volume: 269 m^3, 9,500 ft^3)
(b) Cubicle 3 (Volume: 92·8 m^3, 3,280 ft^3)
(c) Recording Channel W3 (Volume: 78·7 m^3, 2,780 ft^3)
(d) Narrator's Studio (Volume: 60·3 m^3, 2,130 ft^3)

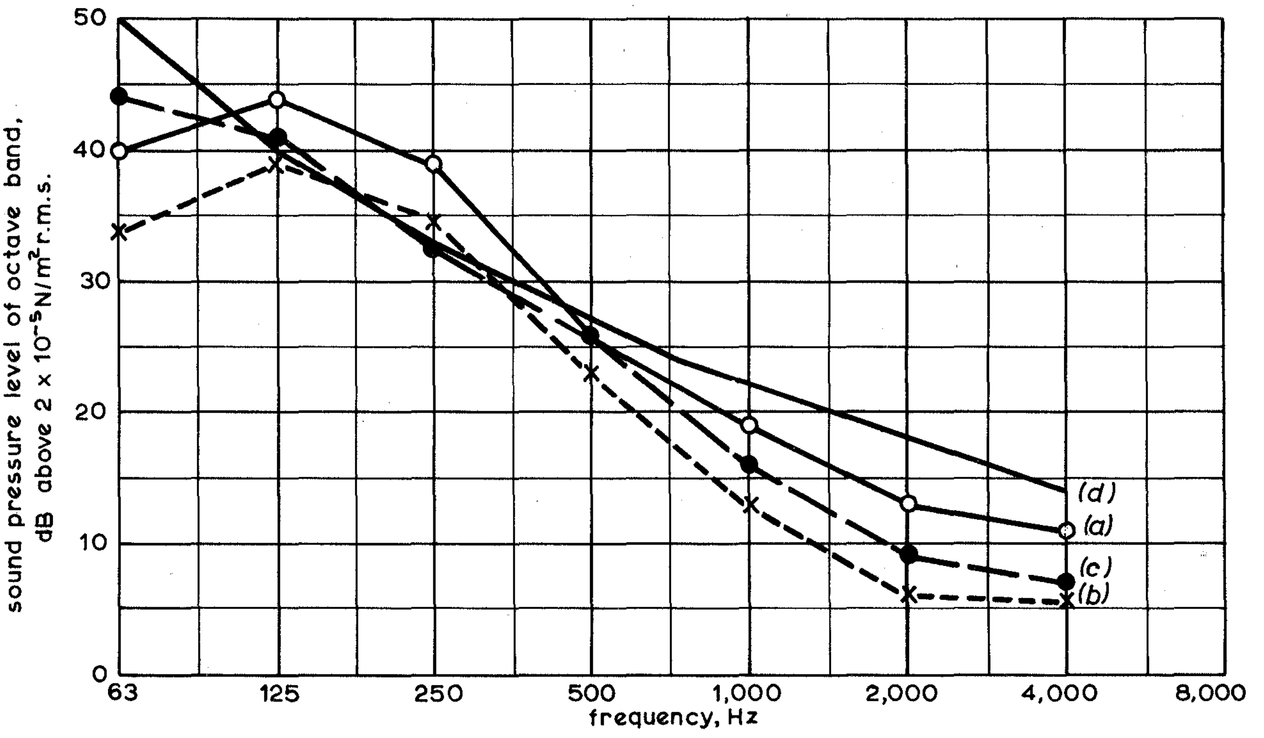

Fig. 8. Background noise levels in Studio 2 Suite

(a) Studio 2 *(b)* Cubicle 2 *(c)* Recording Channel W2
(d) Criterion curve of permissible background noise in sound studios (except drama)

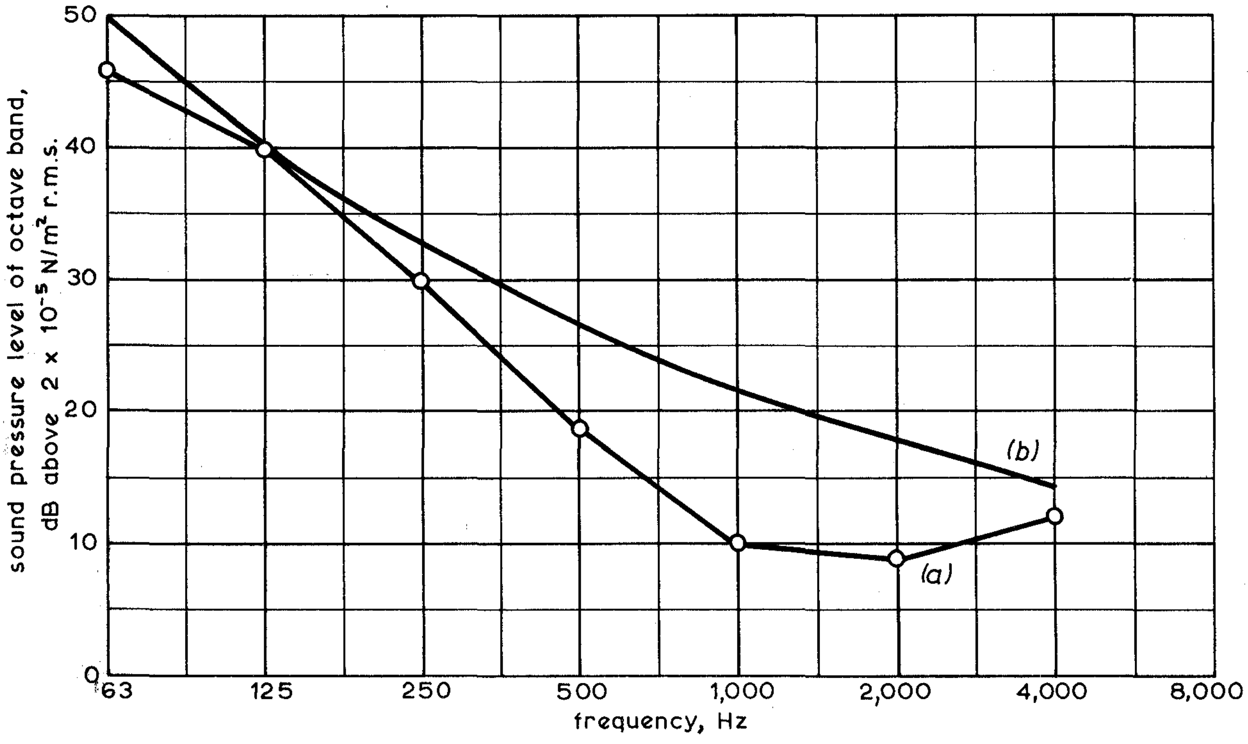

Fig. 9. Background noise levels in Narrator's Studio

(a) Studio noise

(b) Criterion curve of permissible background noise in sound studios (except drama)

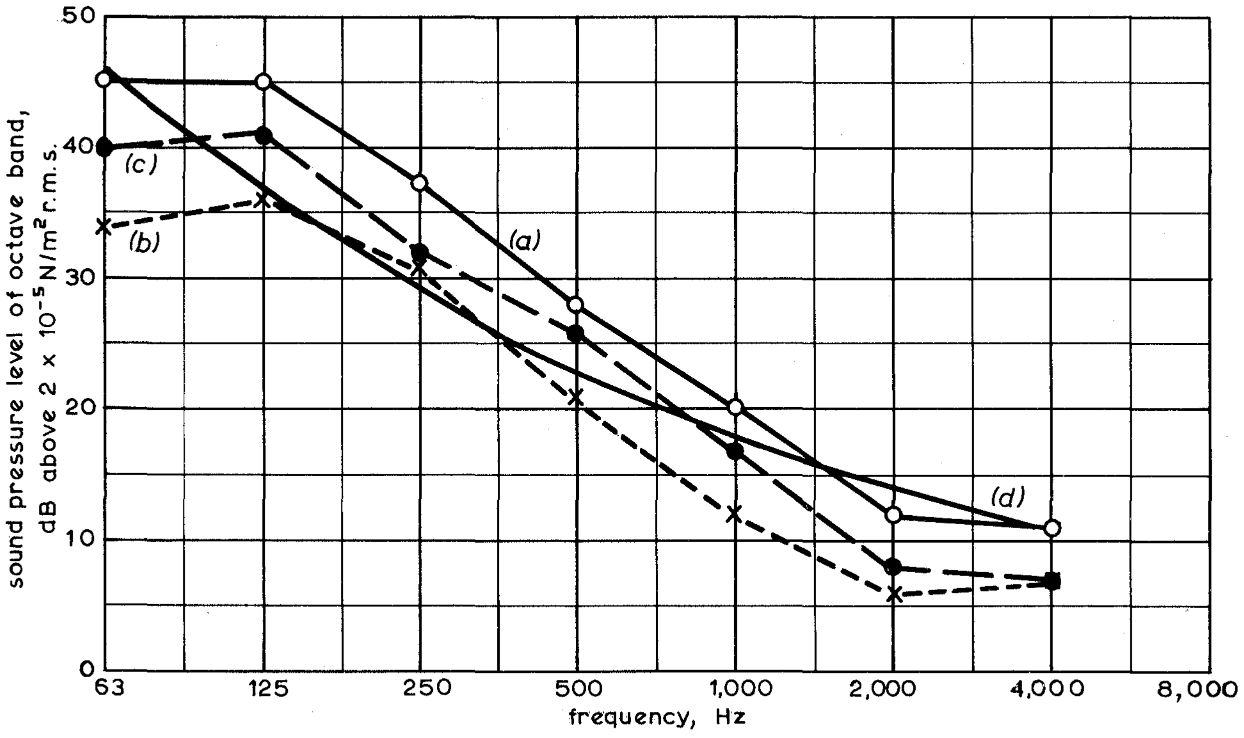

Fig. 10. Background noise levels in Studio 3 Suite

(a) Studio 3 *(b)* Cubicle 3 *(c)* Recording Channel W3

(d) Criterion curve of permissible background noise in a sound drama studio

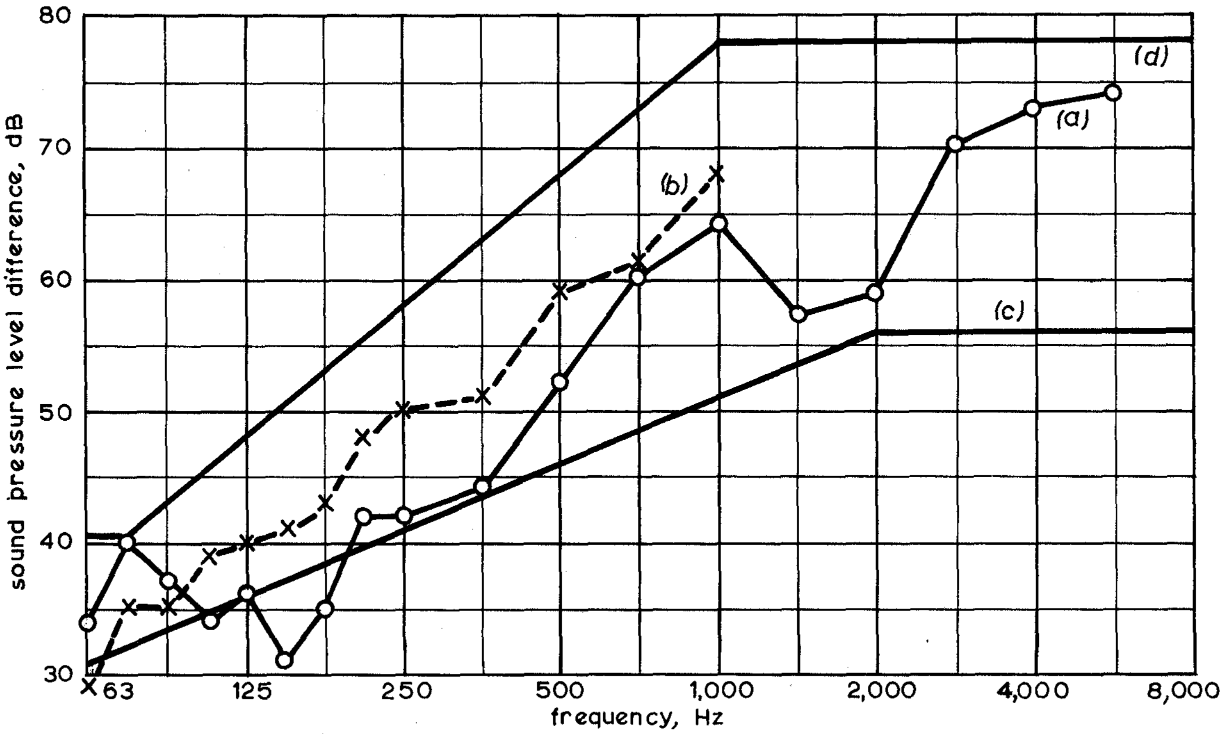

Fig. 11. Sound insulation in Studio 2 area

(a) Recording Channel W2 to Cubicle 2 *(b)* Studio 2 to Narrator's Studio
(c) Insulation criterion for Cubicle to adjacent Cubicle
(d) Insulation criterion for Music Studio to Talks Studio

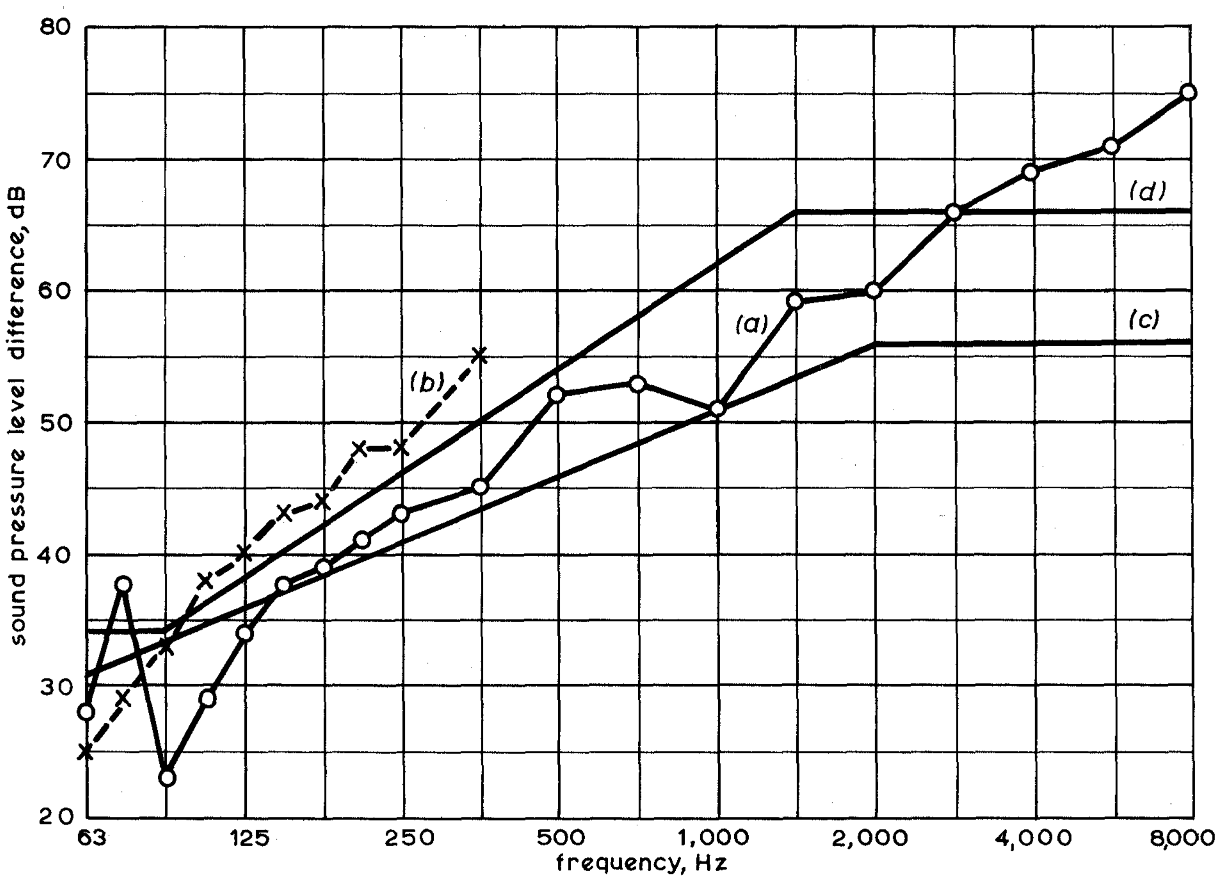

Fig. 12. Sound insulation in Studio 3 area

(a) Recording Channel W2 to Cubicle 3. (criterion *(c)* applies)
(b) Studio 3 from Narrator's Studio. (criterion *(d)* applies)
(c) Insulation criterion for Cubicle to adjacent Cubicle
(d) Insulation criterion for Talks Studio to Drama Studio.

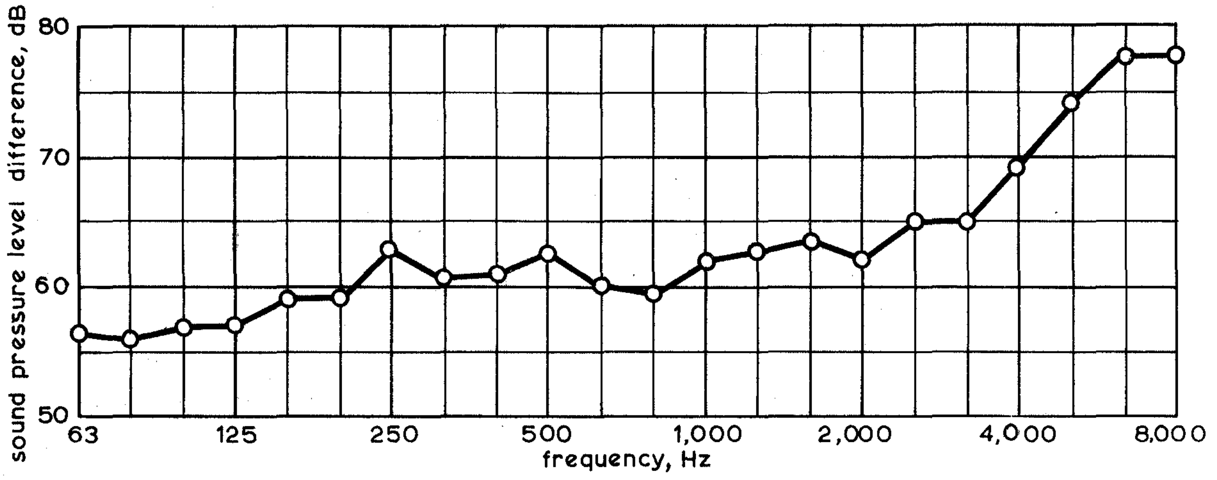

Fig. 13. Insulation of Studio 5 from exterior

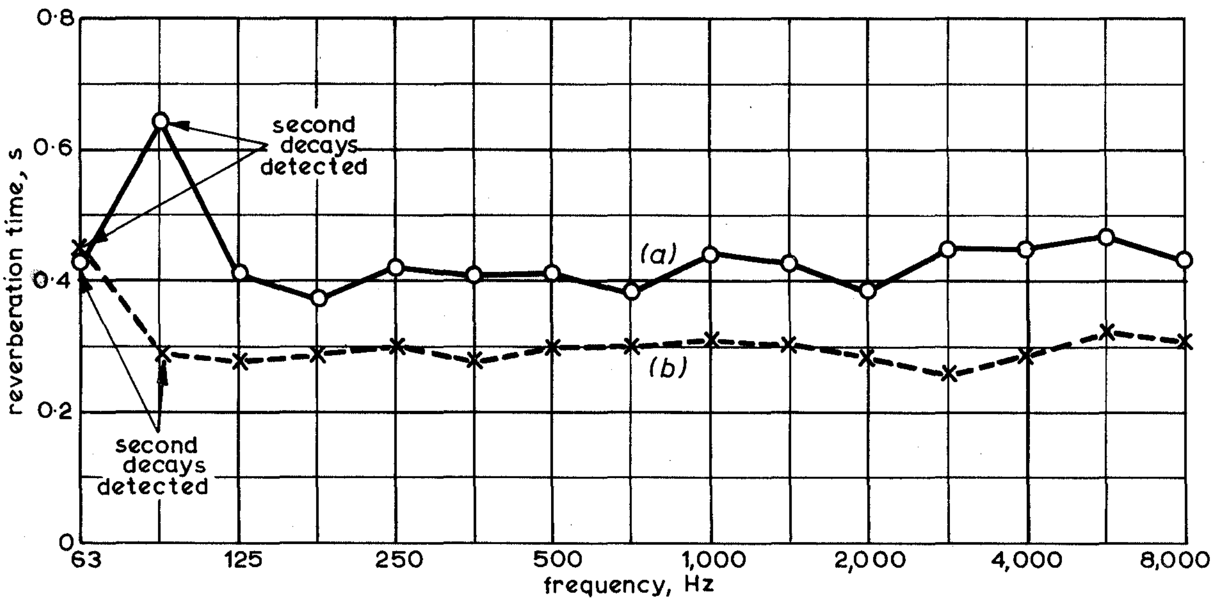

Fig. 14. Reverberation times in Studio 4 and Cubicle

(a) Studio 4 (Volume: 144 m^3, 5,080 ft^3)
(b) Cubicle 4 (Volume: 62·2 m^3, 2,200 ft^3)

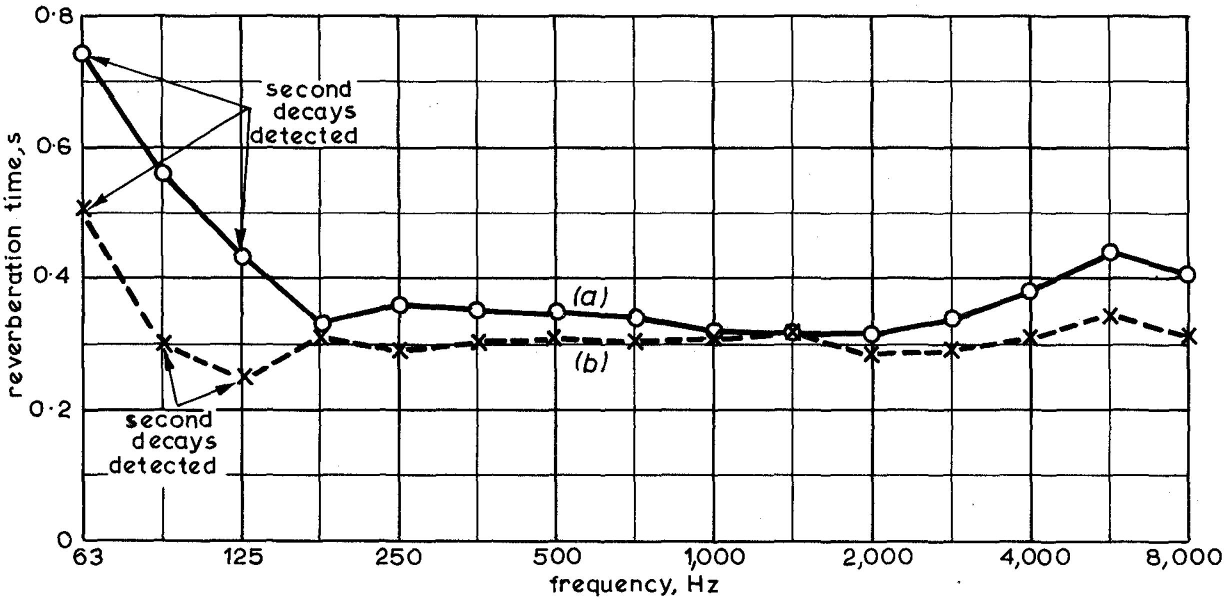

Fig. 15. Reverberation times in Studio 5 and Cubicle

(a) Studio 5 (Volume: 82 m^3, 2,900 ft^3)
(b) Cubicle 5 (Volume: 62·2 m^3, 2,200 ft^3)

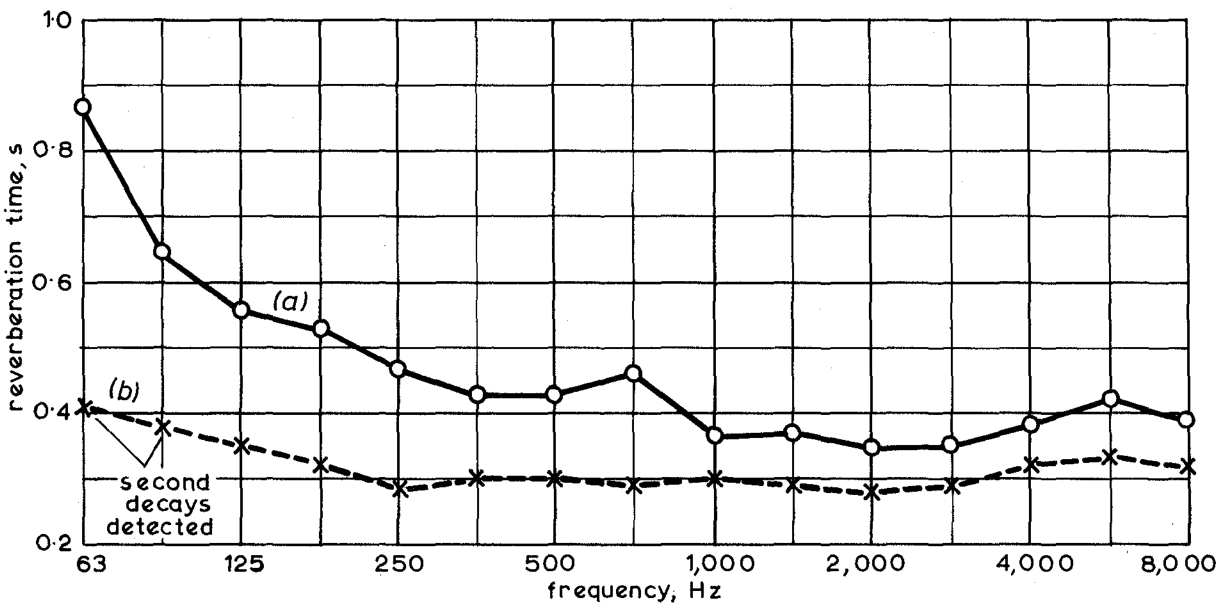

Fig. 16. Reverberation times in Studio 6 and Cubicle

(a) Studio 6 (Volume: 82 m^3, 2,900 ft^3)
(b) Cubicle 6 (Volume: 86 m^3, 3,040 ft^3)

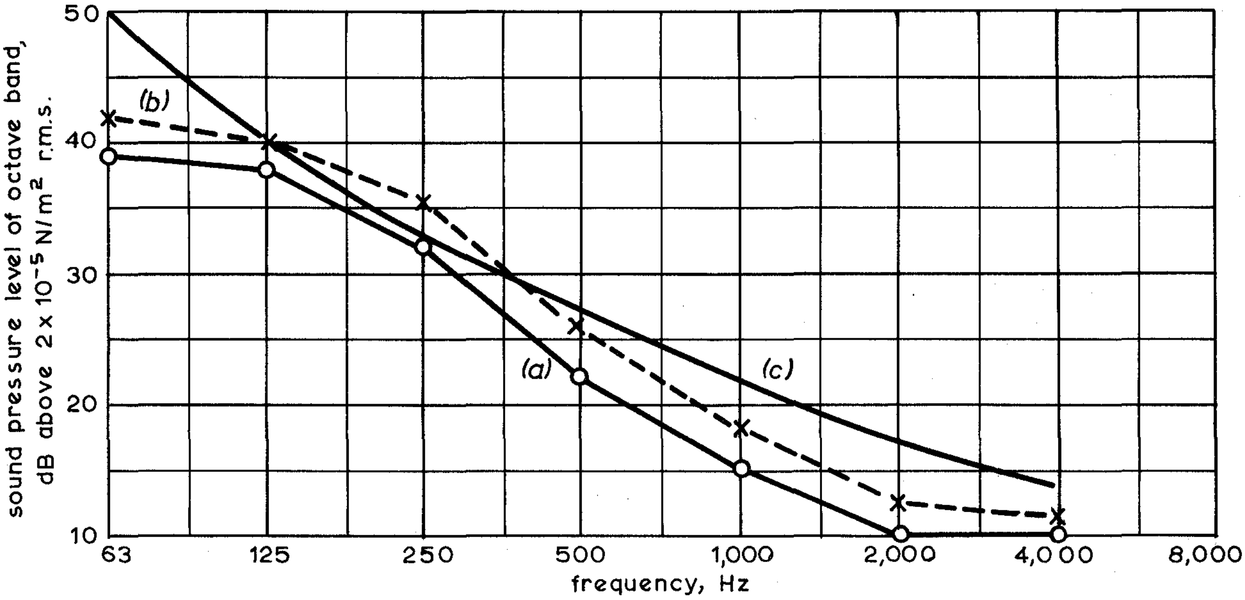

Fig. 17. Background noise levels in Studio 4 and Cubicle

(a) Studio 4 (b) Cubicle 4

(c) Criterion curve of permissible background noise in sound studios (except drama)

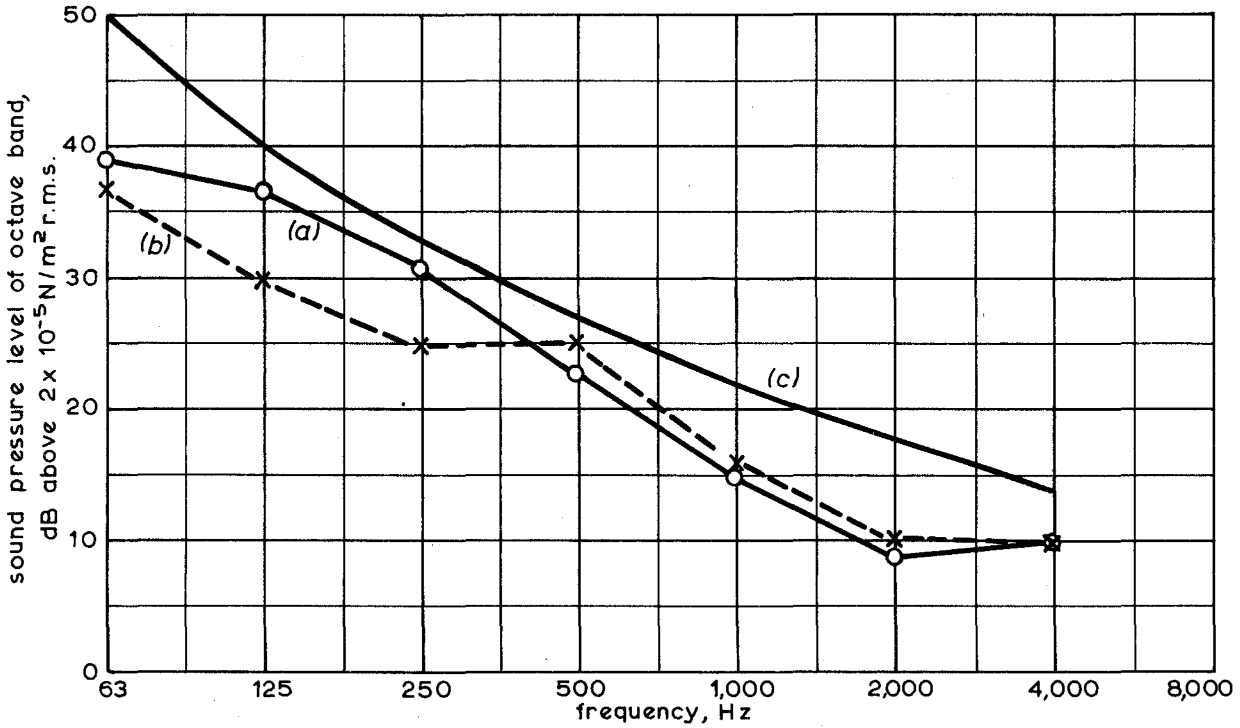

Fig. 18. Background noise levels in Studio 5 and Cubicle

(a) Studio 5 (b) Cubicle 5

(c) Criterion curve of permissible background noise in sound studios (except drama)

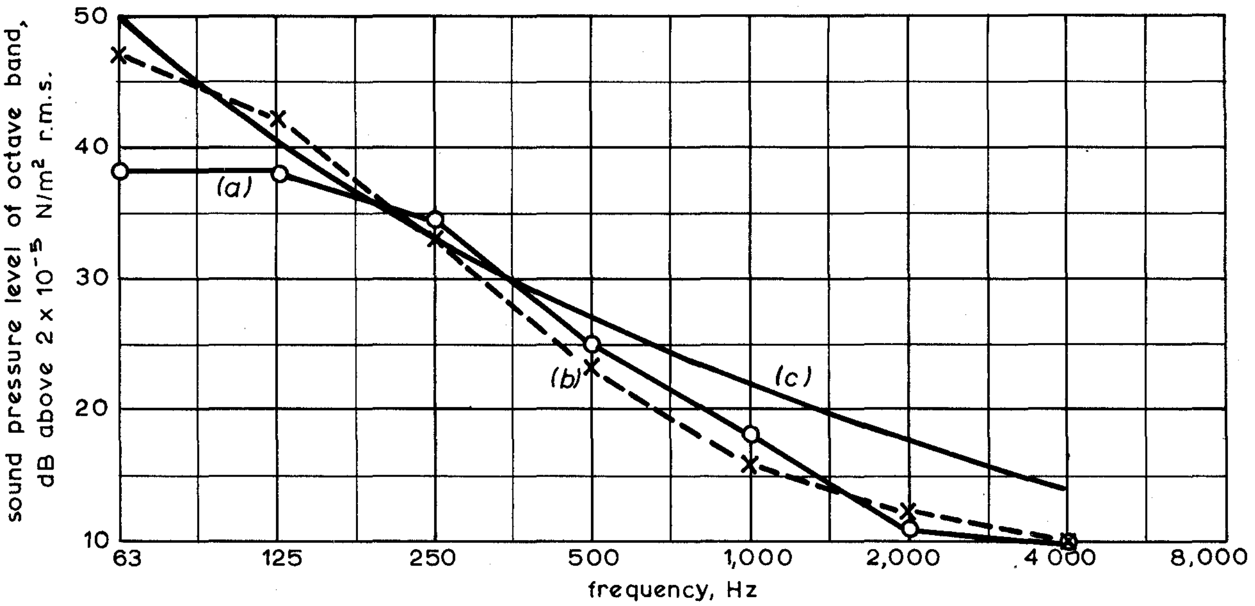

Fig. 19. Background noise levels in Studio 6 and Cubicle

(a) Studio 6 *(b)* Cubicle 6

(c) Criterion curve of permissible background noise in sound studios (except drama)

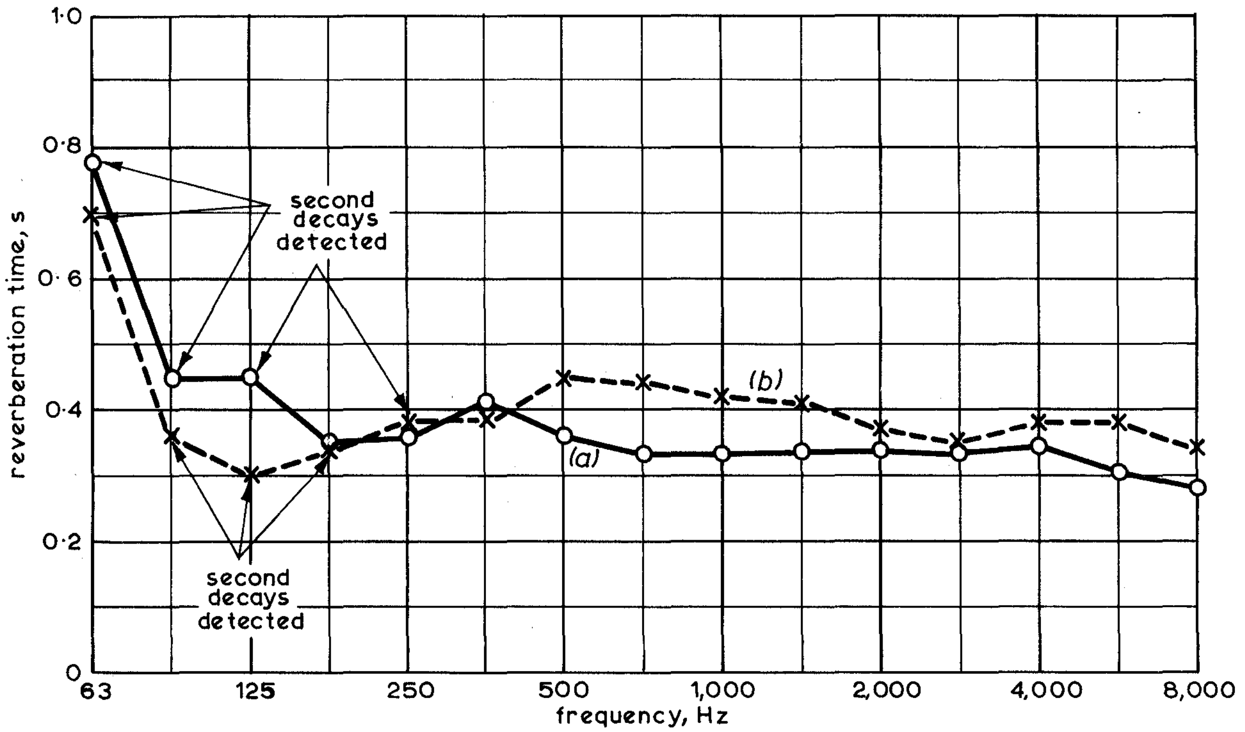

Fig. 20. Reverberation times in Studio 7 Suite

(a) Studio 7 (Volume: 66 m^3, 2,330 ft^3)

(b) Editing Channel W7 (Volume: 94·2 m^3, 3,330 ft^3)

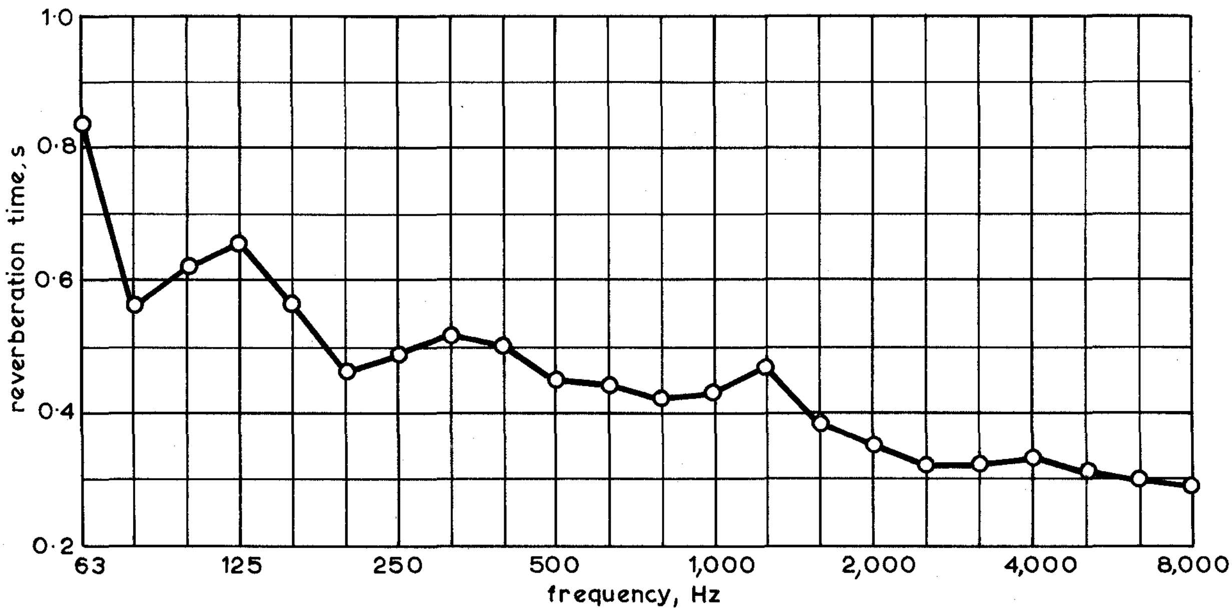

Fig. 21. Reverberation times of Editing Channel W8 from computer analysis of tape recording (Volume: 94·2 m^3, 3,330 ft^3)

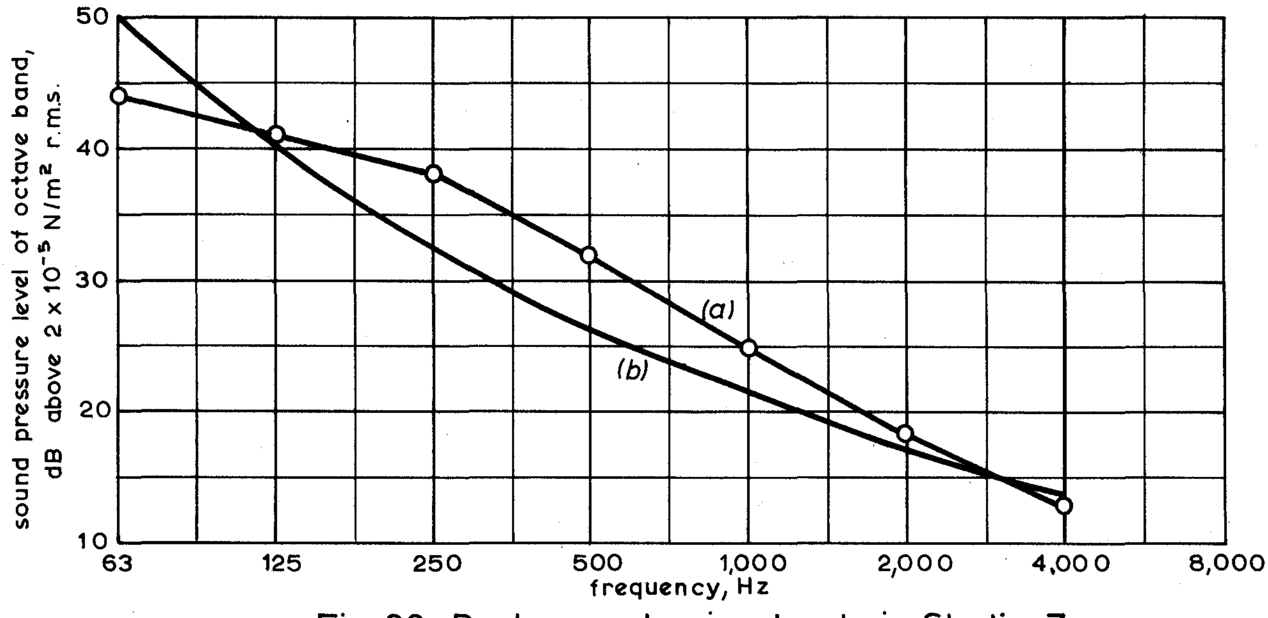

Fig. 22. Background noise levels in Studio 7

(a) Studio 7

(b) Criterion curve of permissible background noise in sound studios (except drama)

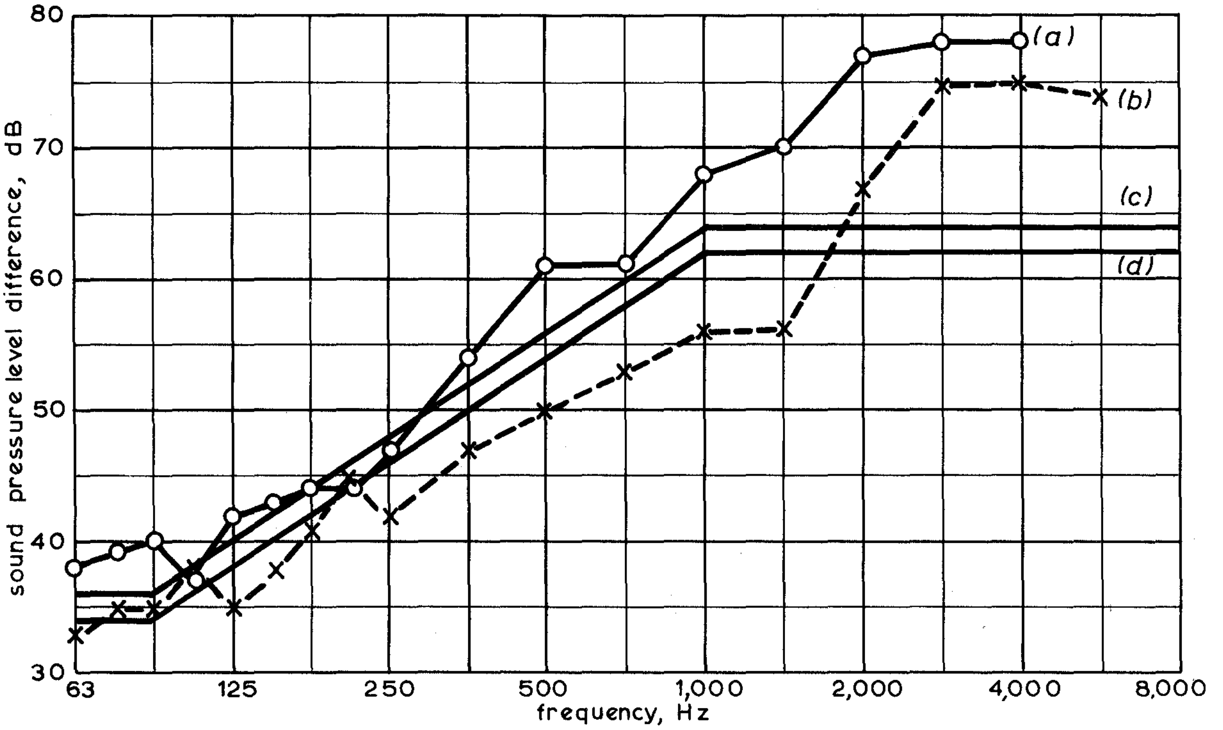

Fig. 23. Sound insulation in Studio 7 area

(a) Studio 7 to Editing Channel W8 (criterion *(c)* and *(d)* can apply)

(b) Studio 7 to Editing Channel W7 (criterion *(c)* applies)

(c) Insulation criterion for a talks studio to a recording room

(d) Insulation criterion for a talks studio to a cubicle monitoring another programme

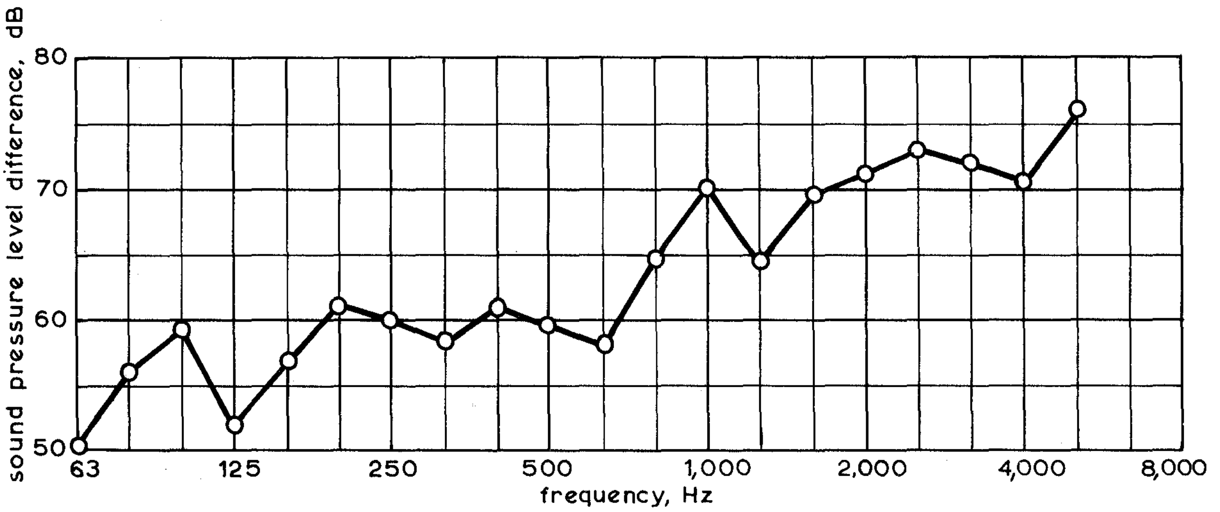

Fig. 24. Insulation of Studio 7 from exterior

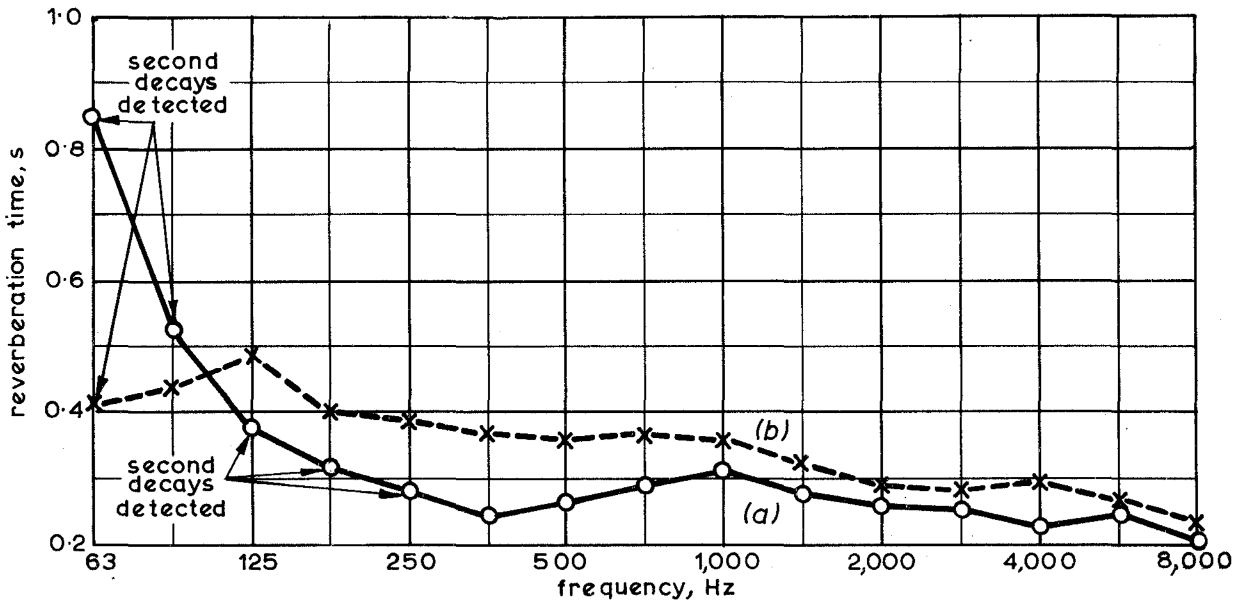

Fig. 25. Reverberation times in Continuity Suite (Studio 8)

(a) Continuity Studio 8 (Volume: 59·6 m^3, 2,210 ft^3)

(b) Cubicle 8 (Volume: 89·3 m^3, 3,150 ft^3)

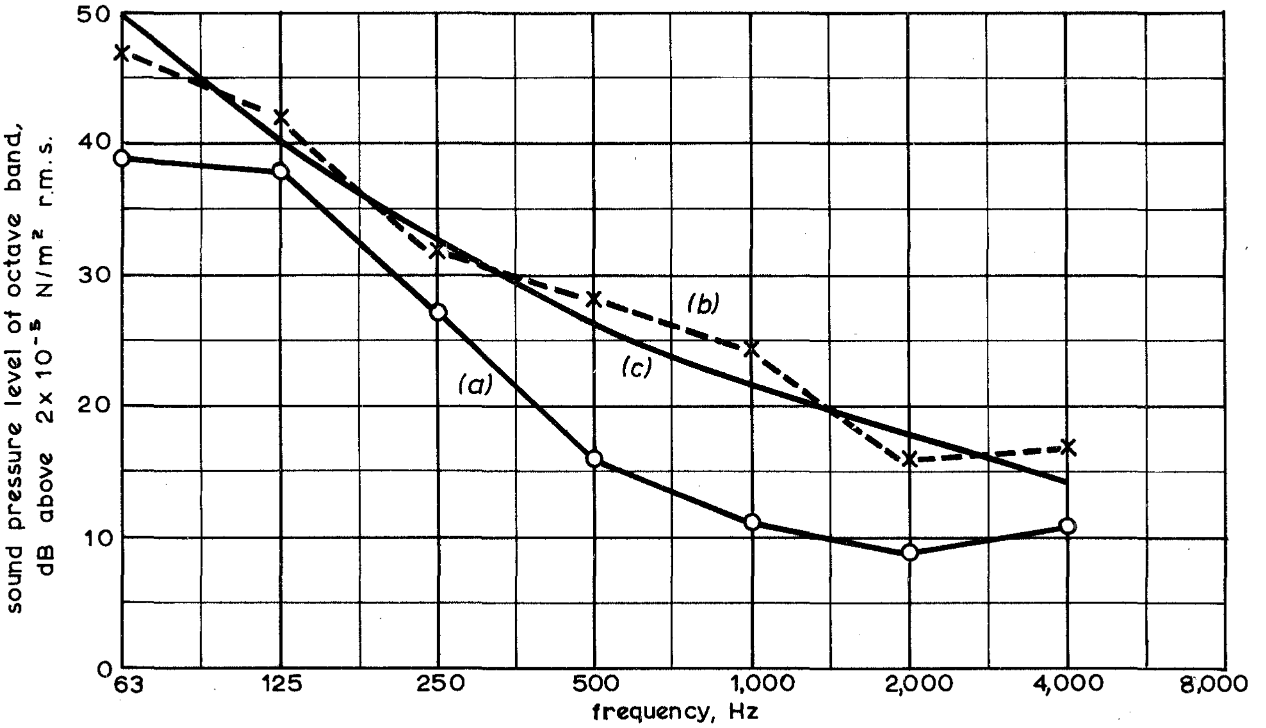

Fig. 26. Background noise in Continuity Suite (Studio 8)

(a) Continuity Studio 8 *(b)* Cubicle 8

(c) Criterion curve of permissible background noise in sound studios (except drama)

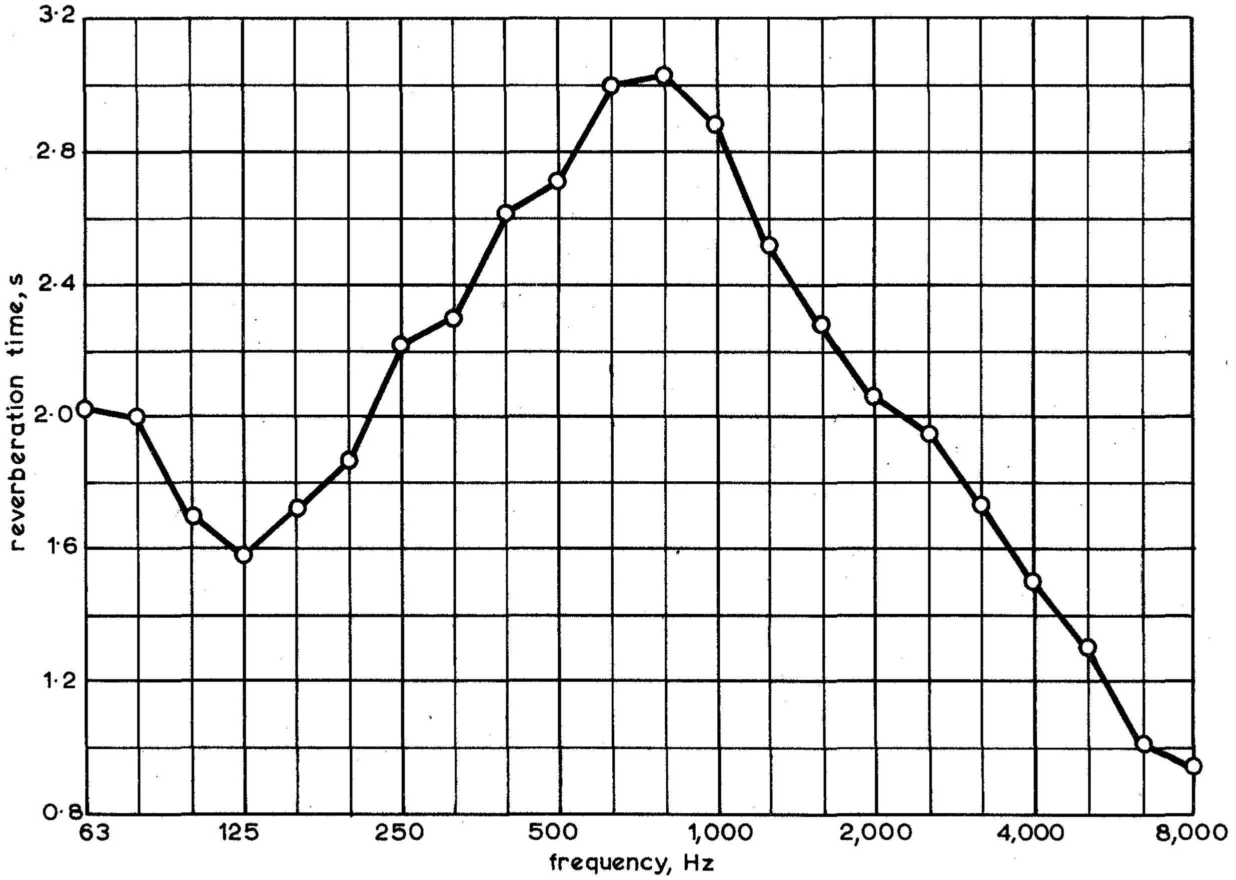

Fig. 27. Reverberation times in Echo Room from computer analysis of tape recording. (Volume: 77·5 m^3, 2,740 ft^3)

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